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Sound Attenuation Characteristics of the DH-133A Helmet

By

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Sensory Research Division

January 1992

United States Army Aeromedical Research Laboratory
Fort Rucker, Alabama 36362-5292

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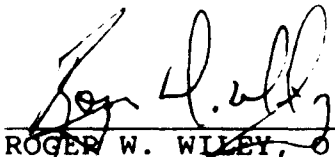

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FIELD	GROUP	SUB-GROUP	Sound attenuation, tanker helmet, hearing thresholds

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This report documents the sound attenuation characteristics of a product improvement of the standard DH-132A helmet. Results indicate the improved helmet exceeds the attenuation required by the specification at all test frequencies and is significantly better than the DH-132 at most frequencies. A spring tension band between the earcups, improves earcup-to-head retention. A thermo-plastic liner improves stability and comfort. All of the improvements are available in kit form for field upgrade of fielded DH-132A helmets.

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Introduction

The current Combat Vehicle Crewman (CVC) helmet, DH-132A, was type classified during the early 1970s. Since then, few modifications have been made to improve its performance. In 1976, a CVC helmet improvement program was started at Natick Research Development and Engineering Command (NRDEC) to determine performance requirements which would lead to product improvements of the DH-132A or requirements documents for new CVC helmet designs. This program was abandoned before completion due to lack of funding.

Gentex Corporation has, through their own efforts, produced a prototype helmet, DH-133A,* which may be considered as an improvement over the current DH-132A. In accordance with the Cooperative Research Agreement for Exchange of Technical Information and Material (see Appendix A)) between Gentex Corporation and the U.S. Army Aeromedical Research Laboratory (USAARL), an evaluation of this improved CVC helmet was requested. This evaluation included a review of the sound attenuation characteristics and general comfort of the helmet. The sound attenuation characteristics of the DH-133A helmet are compared to the DH-132A helmet in this report.

The DH-133A is much like the DH-132A when viewed externally. However several changes make this helmet significantly different. The completed helmet unit comes in three sizes. The insert liner of the DH-132A has been replaced with an earcup retention system, similar to the retention system used in the SPH-4B, which is permanently attached to the ballistic shell. The ballistic shell is lined with a 0.5 inch energy absorbing liner (two sizes) which has Velcro™ hook patches for retention of a removable, thermo-plastic liner (TPL), (three sizes). The TPL is a head piece which may be form fit to an individual by heating to approximately 200 degrees F, placing on the individual's head and allowing it to cool in place. No discomfort is experienced by the person being fit. The TPL may be reheated and refit if desired. The left and right earcups are coupled with a spring wire device (two sizes) which provides a means of applying positive pressure of the earcups to the head. All of the changes incorporated into the DH-133A are available in kit form to upgrade the standard DH-132A Helmet.

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* See manufacturer's list.

Methods and instrumentation

Psychophysical measurements were conducted in accordance with ANSI S12.6-1984, "Method for the measurement of the real-ear attenuation of hearing protectors." S12.6 is a threshold shift method which uses human subjects to determine the difference in threshold when wearing and not wearing the hearing protector. This method uses 1/3 octave bands of noise with center frequencies at 125, 250, 500, 1000, 2000, 3150, 4000, 6300, and 8000 Hz as the stimulus. Evaluations were completed in a hard walled sound room with a nondirectional sound field. A block diagram of the test system is shown in Figure 1.

Ten college students, male and female with normal hearing, were selected as subjects. Hearing thresholds for both ears were required to be no greater than 10 dB at test frequencies from 250 to 1000 hertz and no greater than 20 dB at test frequencies above 1000 hertz. Subjects were evaluated for acceptability using a standard clinical audiometer in accordance with ANSI S3.6-1989 (R1969), "Specification for audiometers."

The method of adjustment psychophysical procedure was used to measure the hearing threshold of the subjects (Nelson and Mozo, 1988). Subjects, one at a time, were seated in the sound room with their heads placed at a fixed location in space. A key pad, controlled by the subject, was used to increase or decrease the stimulus level during the experiment. The subjects were instructed to adjust the stimulus level to their auditory threshold for four separate trials for each of the test frequencies while wearing and not wearing the helmet. The average stimulus level of the four trials at each test frequency was used as threshold for that test condition. Attenuation is defined as the difference between occluded (wearing the helmet) and unoccluded (not wearing the helmet) thresholds. The attenuation for each of the test frequencies was measured for three fittings of the hearing protector for each of the subjects in the evaluation. The attenuation for each fitting of the 10 subjects was calculated into average and standard deviation values for each of the test frequencies.

The objective procedures, IAW MIL-STD-912 "Physical ear noise attenuation testing," used miniature microphones placed at the ear canal opening of the subject. The subject was placed in a wideband nondirectional sound field while the microphone output from each ear was analyzed into one-third octave band levels (see Figure 2). The subject then donned the hearing protective device and again the microphone output was analyzed from each ear. The difference in level between wearing and not

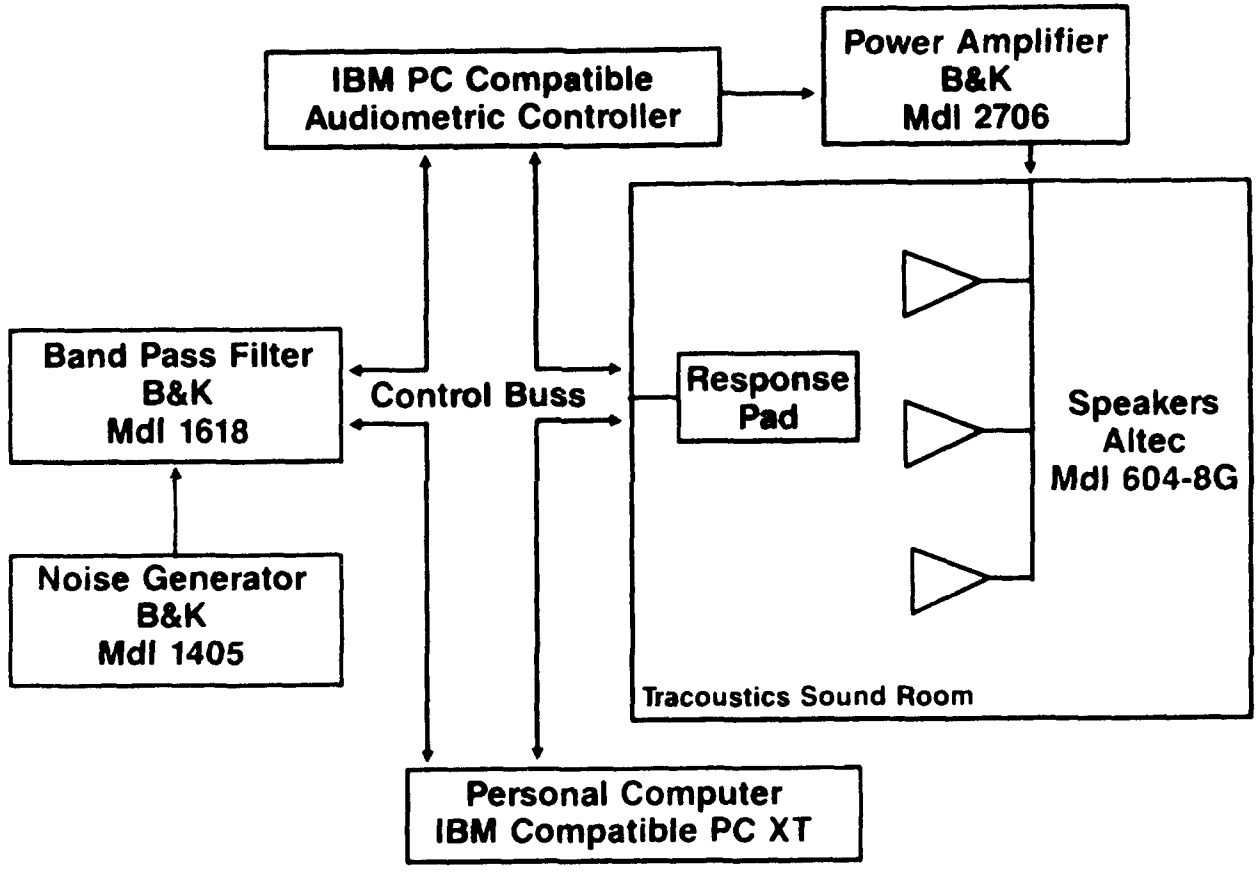

Figure 1. Real-ear attenuation test system measurement standard S12.6.

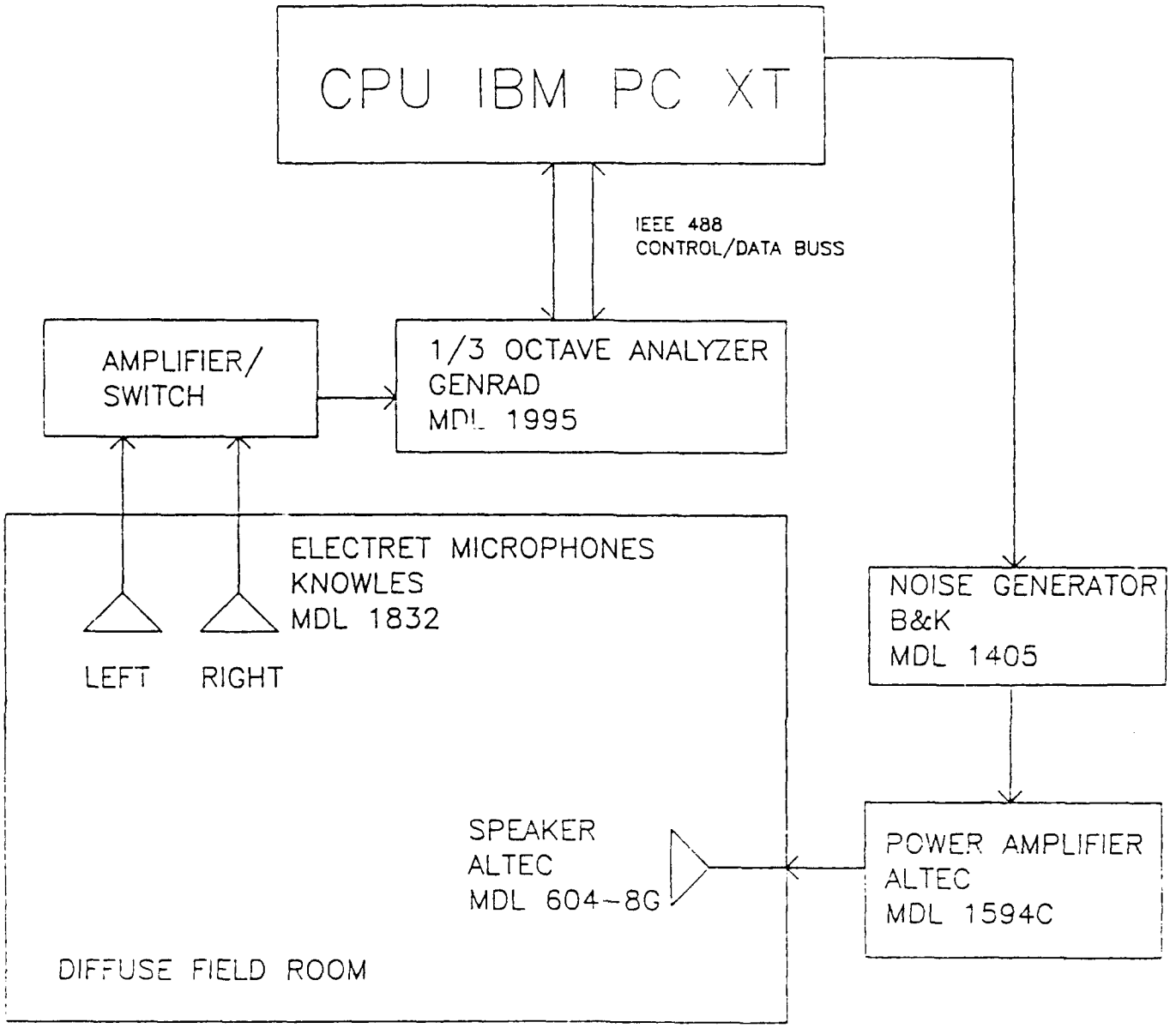

Figure 2. **Physical-ear attenuation test system.**

wearing the hearing protector was defined as the physical ear attenuation test (PEAT) attenuation. The procedure of measuring the levels with the hearing protector in place was repeated two more times. The PEAT attenuation was an average of 3 evaluations for each of 10 subjects.

Results and discussion

Results of the sound attenuation evaluation indicate the DH-133A helmet exceeds the requirements of MIL-H-44117A (December 86) "Helmet, combat vehicle, ballistic shell, DH-132A" at all frequencies. No discomfort from wearing the helmet was indicated by any of the subjects during evaluation.

Table 1 shows the real-ear attenuation characteristics of the helmets. Comparisons of the DH-133A and DH-132A First Article show notable improvements in attenuation for all frequencies except 6300 hertz and 8000 hertz. Comparisons of the DH-133A and DH-132A with tension spring and #7 earseal show significant improvement at all frequencies except 2000, 4000, 6300, and 8000 hertz. The improvements were determined to be statistically significant using the Student's t-test with alpha = 0.05. The DH-133A and DH-132A with tension spring and #7 earseal attenuation characteristic exceeded the requirements at all frequencies. The DH-132A First Article failed to meet the requirement at 2000 hertz.

Table 1.

Mean and standard deviation of real ear attenuation characteristics of three Gentex helmets.

		Test frequencies in hertz								
		125	250	500	1K	2K	3.15K	4K	6.3K	8K
DH-133A USAARL	Mean	19.8	21.9	28.8	31.4	32.0	37.7	36.6	36.4	34.1
	S.D.	5.2	4.3	4.7	3.6	4.9	5.9	5.5	4.6	4.5
DH-132A First Article	Mean	14.4	18.7	25.9	24.8	21.7	33.9	34.1	34.6	32.5
	S.D.	3.0	3.8	4.5	4.1	4.7	4.9	4.0	3.7	4.3
DH-132A With spring using #7 earseal	Mean	15.3	19.4	24.3	27.4	30.5	35.2	35.7	38.2	35.2
	S.D.	4.0	4.3	4.2	4.8	4.2	5.3	4.3	2.9	3.4
Minimum acceptable attenuation values		14	16	21	23	28	35	35	35	30

Pressure of an earcup to the wearer's head was highly correlated to the resultant attenuation. Pressure of earcup to head for the DH-133A helmet was controlled by the back nape strap, the manner in which the earcup retainer was attached to the helmet shell, the chin-strap, and the spring wire assembly which couples the two earcups. The physical-ear attenuation was measured with and without the spring tension device in place in order to evaluate its effect. Table 2 shows a comparison of attenuation when measured on five individual subjects. No significant differences were indicated.

Table 2.

Physical-ear attenuation characteristics of the DH-133A with and without spring tension band.

		Test frequencies in hertz								
		125	250	500	1K	2K	3.15K	4K	6.3K	8K
With spring	Mean	10.3	17.9	27.6	35.4	41.6	36.6	38.2	37.6	36.6
Without spring	Mean	11.0	18.4	27.2	35.7	40.4	37.8	39.8	38.0	36.6

Improvements in sound attenuation will increase allowable noise exposure times for crewmen in most U.S. Army combat vehicles. Table 3 shows a comparison of calculated effective noise exposure for CVC helmets when used in the Bradley Fighting Vehicle (BFV) during forward speed of 40 MPH. The 3.4 dB reduction in noise exposure when wearing the DH-133A results in a 65 percent increase in allowable exposure time, IAW TB-MED-501 "Hearing conservation," in that particular noise environment.

Comments from research subjects involved in the attenuation test suggest the DH-133A was more comfortable than the DH-132A. Positive comments also were received from a National Guard soldier who used the helmet for training exercises in an M-60 tank.

Table 3.

Estimated exposure level in dBA of three CVC helmets in the BFV at 40 MPH.

	DH-133A USAARL	DH-132A First Article	DH-132A With spring using #7 earseal
Real-ear	99.0	102.4	102.3
Physical-ear	102.5	105.4	105.9

Conclusions and recommendations

The sound attenuation of the DH-133A is significantly better than the current CVC helmet. Fit and comfort also are improved in the DH-133A. Further consideration of the DH-133A helmet for use in the CVC environment is recommended.

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Appendix A

Cooperative Research Agreement for Exchange of Technical Information and Material (Agreement DAMD17-89-0388).

COOPERATIVE RESEARCH AGREEMENT FOR EXCHANGE OF TECHNICAL INFORMATION AND MATERIAL

Between

GENTEX Corporation
Carbondale, PA 18407
(Hereinafter Called the Company)

and

U.S. Army Aeromedical Research Laboratory
Fort Rucker, AL 36362-5292
(Hereinafter Called the Laboratory)

1. PURPOSE: The exchange of technical information and material to further the development of improved life support and personnel protective devices, systems and components (hereinafter called products) for military medical purposes. The goal of the Laboratory is to assure the availability and effectiveness of appropriate life support and protective material to prevent loss of life and injury to personnel during the accomplishment of their military mission.

2. TESTING AND EVALUATION: From time to time the Company may supply products of potential military medical importance, patented or unpatented, for testing and/or evaluation by the Laboratory. These products are to be evaluated against known or anticipated requirements and specifications, except as specifically excluded by the Laboratory. This may necessitate access to Laboratory facilities, offices, or testing laboratories by technical representatives of the Company. It is understood that the Laboratory shall not be obligated to test any product supplied by the Company. The products will be evaluated by the Laboratory, and will not be made known to or placed in laboratories of any other company, particularly in the life support or protective devices industries, without prior written permission of the Company. The Laboratory acknowledges that the act of testing and evaluation of products submitted by the Company will not, in and of itself, cause the Laboratory to acquire or share in product rights-in-data as established by the Company.

3. RECORDS:

a. The Company shall forward to the Laboratory, the products to be tested together with data sheets, or specifications for each product, and any precautions which need to be followed in use, handling, storing, and shipping.

b. It is clearly understood that no data about the products and the results of the testing will be kept by the Laboratory in files open to the public. Only those Laboratory employees whose duties require knowledge, and those directly engaged in the research and development, will have access to the files of information regarding source and nature of materials and results of testing.

c. The Laboratory shall return to the Company any products which the Company may designate at any time before actual testing has started or within six months if the testing has already commenced. In the event destructive testing is required, the Laboratory shall not be held liable by the Company for the cost of such products.

4. PATENT RIGHTS: In the event an invention is made solely by a representative of one of the parties to this agreement with respect to any product supplied under this agreement, the party making the invention shall have the primary right to file the patent applications, foreign or domestic, on such invention. In regard to any joint invention for which the Company receives a patent, then the Laboratory on behalf of the United States Government, shall have a non-exclusive, non-royalty bearing license, for the life of the patent, to practice or have practiced the invention of such patent by or on behalf of the U.S. Government. In regard to any joint invention for which the Laboratory receives a patent, then the Company shall have a non-exclusive, non-royalty bearing license for the life of the patent, to practice and have practiced the invention of such patent on its own behalf. In the event there is a joint invention by the Company and the Laboratory with respect to any product supplied under this agreement, the Company shall have the primary right to file the patent applications, foreign or domestic, on such invention. If the party which has the primary right to file the patent applications has not filed a U.S. patent application within one (1) year after the invention was made, then the other party may file the U.S. patent application at its own expense. Both parties agree to cooperate in good faith in securing and transmitting to the other, such instruments of writing as are necessary to fulfill the terms and conditions of this agreement. Within two (2) months after a written request by the other party, the party which owns such application will execute and deliver to the other party such instruments of writing as may be necessary to confirm the license or licenses granted by this agreement.

5. REPORTS: As soon as tests are completed the Laboratory will provide the Company a full report including all test data. The Laboratory shall be consulted whenever the Company desires to include the Laboratory's data in a scientific publication. The

Laboratory will allow subsequent publication by the Company in consideration for appropriate credit being given to the Laboratory.

6. PUBLICATIONS:

a. With regard to results of testing products in which the Company has a proprietary interest, and that the Laboratory deems significant for the furtherance of research, the Company agrees that the Laboratory may publish such results after a period of six months from the date of final reporting of results to the Company. (Subsequent categorization as "Company Confidential" or "Company Proprietary" will be honored when trade secrets or such private information must be safeguarded and will not be published by the Laboratory.) Publication of data within the six month period requires prior written consent of the Company; such consent shall not be withheld unreasonably.

b. Distribution of reports will be provided to Government agencies upon their request. Distribution will be limited to those agencies listed in Appendix A, except as mutually agreed upon by the testing laboratory and the Company.

c. Neither the name of the Laboratory, nor the name of any other agency of the Government, shall be used by the Company in publicity relating to the subject of this Agreement or for any commercial promotional purposes without prior written approval of the Laboratory or other associated Government agency.

7. USES OF PRODUCTS: The Laboratory will test products against appropriate standards for military use. It is understood that the Company has no control over the Laboratory's use of the products submitted hereunder and shall not be liable for any injury or damages, direct or consequential, which may result from the Laboratory's use or testing of such products. No studies involving the use of humans will take place under this agreement. Any studies involving human subjects will be the subject of a subsequent special agreement between the Laboratory and the Company.

8. EXPORT CONTROL: The Company and its affiliates shall not, without the prior written approval of the Laboratory, transfer technical information to companies and/or countries prohibited, concerning the products submitted by the Company and tested by the Laboratory, pursuant to the export control regulations of the Department of Commerce [15 C.F.R. 370 (Supplement 1)] Country Group W, Y, and Z.

9. NON-DISCLOSURE: The parties, through their representatives anticipate communication of certain confidential and/or proprietary information considered to be trade secrets of the

Company. The Laboratory agrees that such information communicated to it by the Company will be held in utmost confidence. Specifically, it is agreed that representatives of the Laboratory will maintain in confidence knowledge of the technical data, processes, designs, products, equipment, special tools, work in process, and other such information acquired while in communication with the Company, its personnel, or its facilities. This confidence shall be held until or unless such knowledge:

a. is or becomes part of the public domain;

b. is demonstrated by clear and convincing evidence to be known prior to disclosure by the Company (or its representatives);

c. is subsequently rightfully received from a third party, not himself/herself in breach of a duty to the Company not to disclose.

10. TERM: This Agreement will remain in effect for two years; renewal will be initiated by the Laboratory. This Agreement may be terminated by either party for any reason at any time prior to its expiration by giving thirty (30) days written notice to the other party. Termination for any reason shall not affect the rights and obligations of either party with respect to products already submitted for testing and evaluation prior to the date of such termination. This agreement will become effective as of the date of the last signature of either of the authorized representative of the parties.

11. AUTHORITY: The Federal Technology Transfer Act of 1986, 15 USC 3710a, provides each Federal agency with the authority to permit the Director of Government-operated Federal Laboratories to enter into Cooperative Research and Development Agreements (CRDA) with Federal or non-Federal entities including private firms and organizations. This authority allows Federal laboratories to accept, retain, and use funds, personnel, services, and property from collaborating parties and, provide personnel, services, and property to collaborating parties. This authority also includes the disposition of patent rights in any inventions which may result from such collaboration or which are owned by the Government. All prior reviews and approvals required by regulations or law have been obtained by the Laboratory prior to the execution of this Agreement. The Laboratory official executing this agreement has the requisite authority to do so. Notwithstanding the delegation of authority to execute this Agreement to the individual Laboratory official, the Secretary of the Army has reserved to the Assistant

Secretary of the Army (Research, Development and Acquisition) the opportunity provided by 15 USC Sect. 3710a(c)(5)(A), to disapprove or require the modification of this Agreement within 30 days of the date it is presented to him or her by the Laboratory.

IN WITNESS WHEREOF, the Parties have caused this agreement to be executed by their duly authorized representatives as follows:

For the Company:

L. Peter Frieder, Jr., President

Gentex Corporation
P.O. Box 315
Carbondale, PA 18407

DATE 28 APRIL 1989

For the U.S. Government:

DAVID H. KARNEY, Colonel, Medical Corps, Commander, U.S. Army Aeromedical Research Laboratory, Fort Rucker, Alabama

DATE 21 April 1989

Appendix B

Manufacturer's list

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Cleveland, OH 44142

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Natick, MA 01760

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Fort Monmouth, NJ 07703-5401

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